

DESCRIPTION**ARTIFICIAL STONE WALL PANEL****THECHNICAL FIELD**

The invention of this application relates to an artificial stone wall panel and a process for producing the same. More specifically, the invention of this application relates to an artificial stone wall panel which has excellent design, enables easy installation and which is useful as a wall finishing material for architecture and construction.

BACKGOUND ART

External walls of large structures such as buildings have been finished by directly applying coating or tiling to the surface of a concrete body at the construction site or, as in a curtain wall, by precast-molding or connecting a concrete body and a finishing material at a factory and fabricating at the construction site.

On the other hand, for an external wall of a structure such as a house, large panels, such as siding boards subjected to premolding and precoating to form irregular external surface, fixed on a stud or a base panel made of wood or steel has been generally widespread.

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ATTACHMENT B

For example, in case of ceramic siding boards which are most frequently used as external wall materials of houses, the boards are generally installed by adhering or connecting through post treatment engagement fittings on a wall of the house through a stud or a base panel made of wood or steel.

Although the use of such siding boards improves the design of external walls and allows a variety in selection of design, the adhesion or connection of the engagement fittings through post treatment and the installation of the boards on the surface of the external wall were laborious and costly, and were great restriction factors in construction and cost.

Thus, mold-integrating of the engagement fittings during the molding of the siding boards has been studied. However, ordinary cement or ceramic sidings have been problematic in that, in such mold-integrating, warpage and cracks could not be avoided during cure shrinkage of the products.

Meanwhile, in some ALC panels and precast concrete panels having a thickness of more than 50 mm, an example of mold-integrating and embedding by first welding and fixing an engagement fitting to the reinforcement steel and then pouring ready-mixed concrete, is known. Here, the reinforcement steel and the fittings to be embedded

are located on the surface and the back at a nearly central position or a nearly symmetrical position from the center of the cured product to prevent warpage and cracks by cure shrinkage. However, such ALC panels and pre-cast concrete panels have an artificial appearance with little natural texture, and are also heavy in weight. Also, the shape and position of the fittings were characteristically restricted.

Under these circumstances, as a product that can realize designs with a more natural texture, an artificial stone, which is a molded product of a mixture of resin, natural stone and mineral has attracted much attention, and attempts have been made to mold-integrate engagement fittings on such an artificial stone. For example, JP-A-6-106549 proposes a method in which a fitting for engagement is held from both the surface and the back by mold-laminating with a molten material obtained by kneading a thermosetting resin and a stone powder. Balance of cure shrinkage of the surface and the back is attempted to suppress warpage. Nevertheless, in this case, only a simple mold-lamination process is attempted, and the molding method is limited. Further, because the relationship between the composition of the molded product and the integration with the fitting has not been taken into consideration, occurrence of warpage and cracks

following integration is not satisfactorily suppressed. Moreover, the design properties and physical properties such as strength for using the artificial stone as an external wall material is not actually taken into consideration.

Consequently, the object of the invention of this application is to provide, upon solving the foregoing problems associated with the prior art, a novel artificial stone wall panel as an external wall material with excellent design, while also simplifying installation to external wall thereby being advantageous in view of productivity, workability and cost, by mold-integrating an artificial stone and a means for installing such artificial stone to an external wall surface; the object of the invention of this application is also to provide a process for producing the same.

DISCLOSURE OF THE INVENTION

For solving the foregoing problems, the invention of this application first provides an artificial stone wall panel comprising: an artificial stone, the composition of which comprises an inorganic fine powder component with a size of from 9.5 mm to 180 μm , an inorganic finely divided component with a size of less than 180 μm and a resin component in an amount of from 7 to 30% by weight based on

the total artificial stone composition, the weight ratio of the inorganic fine powder component to the inorganic finely divided component (inorganic fine powder component:inorganic finely divided component) being in a range of from 1:1 to 5:1; and a support for installing the artificial stone on a wall surface, embedded to the artificial stone, wherein part of the support is exposed at the back surface or edge surface of the artificial stone.

It secondly provides the artificial stone wall panel, wherein the artificial stone composition has a cure shrinkage factor of 0.3% or less, thirdly provides the artificial stone wall panel, wherein the artificial stone composition has a density in the range of from 2.0 to 2.8 g/cm³ after curing, fourthly provides the artificial stone wall panel, wherein the support is embedded at a volume ratio of 80% or less with a depth of 80% or less of the total thickness, and fifthly provides the artificial stone wall panel, wherein the support is a metal fitting.

The invention of this application sixthly provides any one of the above artificial stone wall panels, wherein at least 5% by weight of the inorganic fine powder component is a transparent inorganic component, and seventhly provides the artificial stone wall panel, wherein the surface has an asperity with a depth (height)

of from 1 to 100 mm.

Further, the invention of this application eighthly provides a process for producing an artificial stone wall panel, which comprises: preparing a mixture having a composition comprising an inorganic fine powder component with a size of from 9.5 mm to 180 μ m, an inorganic finely divided component with a size of less than 180 μ m and a resin component in an amount of from 7 to 30% by weight based on the total composition, and a weight ratio of the inorganic fine powder component to the inorganic finely divided component (inorganic fine powder component:inorganic finely divided component) in a range of from 1:1 to 5:1; filling the mixture into a bottom mold; press-molding a support for installing the artificial stone on a wall surface along with a top mold thereby mold-integrating and embedding the support in a way that part of the support is exposed at either the back surface or the edge surface of the artificial stone wall panel, ninthly provides the process for producing an artificial stone wall panel, wherein the press-molding is performed under a pressure of from 1N/cm² to 100 N/cm², and tenthly provides the process for producing an artificial stone wall panel, wherein the resin component is filled in the form of a mixture of two or more of the following: a monomer, an oligomer or a polymer.

In the invention of this application, as described above, on the basis of the findings that in the mold-integrating of the support for installation on the wall surface with the artificial stone, it is indispensable to properly control the composition of the resin material and the inorganic components to be mixed therewith for suppressing the influence accompanied by cure shrinkage of the resin component and that in this control of the composition, aggregates as the inorganic components are stretched with each other in a densely packed state to suppress the shrinkage and the resin component as a binder forms a compact cured texture, the construction of the peculiar requirements therefore has been introduced. That is, in the invention of this application, it is indispensable that the combination of the inorganic fine powder component with the size of from 9.5 mm to 180 μm and the inorganic finely divided component with the size of less than 180 μm is in the range of from 1:1 to 5:1 in terms of a weight ratio and further that the amount of the resin component is in the range of from 7 to 30% by weight based on the total amount of the artificial stone body exclusive of the amount of the support.

In the production process, it is indispensable that the mixture of the resin component and the inorganic components is filled into the lower mold, the support for

installation on a wall surface is pressed along with the upper mold to integrate the support by embedding so as to expose the part of the support to at least one of the back surface and the edge surface of the artificial stone wall panel.

In the invention of this application, it is possible to solve the problems of the prior art, realize the external material excellent in designing property with a natural texture by an artificial stone, maintain a predetermined strength for installation and simplify preparation and work for installation on an exterior wall surface.

BRIEF DESCRIPTION OF DRAWINGS

Figs. 1 and 2 are sectional views and a back surface view showing an example of mold-integrating of a steel frame.

Figs. 3 and 4 are sectional views and a back surface view showing an example of mold-integrating of a combination of a steel frame and an irregularly finished steel plate.

Figs. 5 and 6 are sectional views and a back surface view showing an example of mold-integrating of steel fittings (partial use).

Figs. 7 and 8 are sectional views and a back surface

view showing an example of mold-integrating of an irregularly finished steel plate.

Figs. 9-12 are sectional views and front views showing supports to be integrally molded and sizes thereof.

BEST MODE FOR CARRYING OUT THE INVENTION

The invention of this application has the foregoing characteristics, and the embodiments thereof are described below.

In the artificial stone wall panel of the invention of this application, it is indispensable, as stated above, that the composition of the artificial stone body except the support comprises

<I-1> an inorganic fine powder component with a size of from 180 μm to 9.5 mm,

<I-2> an inorganic finely divided component with a size of less than 180 μm , and

<II> a resin component,

an amount of the resin component <II> being in the range of from 7 to 30% by weight based on the total amount, and a weight ratio of the inorganic components being in the range of

<I-1>:<I-2> = 1:1 to 5:1.

The inorganic fine powder component <I-1> and the inorganic finely divided component <I-2> as the inorganic

aggregates constituting the artificial stone wall material in combination with the resin component <II> effectively suppress the occurrence of warpage or cracks in the mold-integrating with the support, and further realize desired physical properties such as a strength and a hardness. At this time, in realizing the physical properties, it is important to blend the two types of the inorganic components <I-1> and <I-2> different in grain size. This is because with the use of the inorganic components <I-1> and <I-2> different in grain size, a high-density artificial stone wall panel body with the highest fillability by classification is realized. This results in providing, in consideration of the blending amount of the resin component <II>, an artificial stone wall panel having a natural appearance like a natural stone, which panel cannot be estimated, at a glance, to be a resin molded product.

With respect to the blending amounts, it is preferable that the total amount of the inorganic components <I-1> and <I-2> is less than 93% by weight and the amount of the resin component <II> is at least 7% by weight and at most 30 by weight, for example, from 7 to 20% by weight. When the amount of the resin component exceeds 30% by weight, it is difficult to control the cure shrinkage to less than 0.3% even in the molding with a

great pressure exceeding, for example, 50 N/cm², and warpage or cracks might occur.

In the invention of this application, concerning the inorganic components <I-1> and <I-2>, as described above, the amount of the inorganic fine powder component <I-1> with the larger grain size is larger. It is important that in the weight ratio, the amount thereof is from 1 to 5 times that of the inorganic finely divided component <I-2>. When it is less than 1 time, the effect of suppressing the cure shrinkage by stretching of the inorganic fine powder component <I-1> is not sufficient. When it exceeds 5 times, it is difficult to provide the high density, which results in decreasing properties as an artificial stone member, such as a bending strength. Accordingly, these cases are undesirable.

In the artificial stone wall pane of the invention of this application, it is considered that the cure shrinkage factor of the artificial stone body except the support is 0.3% or less, more preferably 0.1% or less. Incidentally, regarding the definition of the "cure shrinkage factor" in the invention of this application, a cure shrinkage factor: S is represented by the following formula 1 wherein A represents a horizontal inner size (in withdrawal from molds) of a mold frame and B represents a horizontal size (measured at room temperature (20°C)) of a

cured product in molding with the mold frame.

[Formula 1]

$$S (\%) = \frac{A - B}{A} \times 100$$

In this case, the size:B of the cured product is naturally a size of the artificial stone body before the support is embedded by molding.

In the invention of this application, it is preferable that the density (after curing) of the artificial stone body is in the range of from 2.0 to 2.8 g/cm³.

With respect to the inorganic fine powder component <I-1> in the foregoing blending amount, at least 5% by weight thereof can be a transparent component as noted above. In this blending, an artificial stone wall panel releasing scattered luminescence that is variable by illumination of natural light or artificial light and its movement, namely by changing an angle or intensity of illumination is realized. This effect is actually brought forth by providing asperity having a depth (height) of from 1 to 100 mm on the surface.

In the foregoing case, the total amount of the inorganic fine powder component may be a transparent component. An amount of the transparent component based on the total amount of the inorganic fine powder component

<I-1> is generally from 5 to 95% by weight, preferably from 10 to 70% by weight.

The types of the inorganic components <I-1> and <I-2> may include various types. One or more of a natural stone powder, a mineral powder, a ceramics powder, a glass powder and a metallic or alloy powder are available. The inorganic fine powder component <I-1> may contain a transparent inorganic fine powder component. As the transparent inorganic fine powder component, one or more of colorless transparent and colored transparent components of quartz, glass, garnet, amethyst and the like are preferably used. As the inorganic fine powder component other than these transparent inorganic fine powder components, for example, natural stones such as granite and marble, molded articles such as a tile which are crushed and classified or sands such as river sand and sea sand which are classified are listed. With respect to advantages of the combined use of river sand, sea sand or dam sedimentary sand, it is considered that they are energy-saving materials without the need of crushing, a fluidity of a mixture before solidification is good because of the round corner of the grain and a natural texture is induced.

Further, as the other inorganic fine powder component, a fine powder component to which a luminous or

fluorescent pigment is coated on its surface by baking or by coating as a coating layer with a resin may be used. A characteristic luminescence or fluorescence is realized more effectively by blending these coated products in an amount of at least 5% by weight based on the total amount.

Such a luminous or fluorescent pigment may be contained as at least a part of the inorganic finely divided component <I-2>.

The resin component <II> as the component constituting the artificial stone wall pane body in the invention of this application may be made of various polymers or copolymers of addition-polymerization, condensation-polymerization or the like, and may be selected upon considering a strength, a weatherability, a water resistance, an oil resistance and the like as a wall material in relation to the use as the wall material. In general, preferable examples thereof include polymers of methyl methacrylate, butyl methacrylate and the like, methacrylic resins as copolymers containing these as a main component, polymers of methyl acrylate, ethyl acrylate, butyl acrylate, acrylic acid and the like, acrylic resins as copolymers containing these as a main component, unsaturated polyester resins, epoxy resins, styrene resins, and composite resins of more than one thereof.

In the artificial stone wall material of the invention of this application, an artificial stone recycle material may be used to supplement at least one of the foregoing <I-1>, <I-2> and <II>. This recycle material may be derived from building materials such as scrap wood and wood for furniture, materials of construction for road or the like, materials produced for disaster prevention or the like, and materials discharged during production. This recycle material is used such that the artificial stone formed by blending the inorganic fine powder component with the size of from 180 μm to 9.5 mm, the inorganic finely divided component with the size of less than 180 μm and the resin component, molding the blend and solidifying the molded product is crushed to a size of from 180 μm to 9.5 mm. These recycle materials are used as at least a part of the inorganic fine powder component <I-1>.

Accordingly, resources are conserved, and costs are reduced.

In this case, when the artificial stone crushed to the size of from 180 μm to 9.5 mm is blended with a transparent grain component, a luminous material or a fluorescent material, a good luminous performance is expected.

The size of the inorganic component in the foregoing

description is from 180 μm to 9.5 mm in the grain and less than 180 μm in the fine grain. This can actually be attained easily by using, for example, a sieve of a nominal mesh defined in JIS Z 8801-1:2000 corresponding to ISO. The grain component with the size of from 180 μm to 9.5 mm can be classified as a component which is passed through a 9.5 mm-mesh sieve and remains on a 180 μm -mesh sieve. The fine grain component can be classified as a component which is passed through a 180 μm -mesh sieve.

In the artificial stone wall panel of the invention of this application, along with the blending characteristics, it is possible that asperity of from 1 to 100 mm are formed on the surface and at least a part of the transparent inorganic fine powder component is exposed to the surface. That the size of the asperity on the surface is in the range of from 1 to 100 mm is effective for releasing scattered luminescence that is variable by illumination of natural light or artificial light and movement thereof. The size of less than 1 mm is not necessarily satisfactory for releasing variable scattered luminescence. The size exceeding 100 mm makes the wall finish member too thick, raises the cost and increases restrictions to structures. Thus, the luminescence is rather impaired. Meanwhile, the exposure of the transparent inorganic fine powder component is also

indispensable. This exposure is realized more effectively by making the amount of the transparent component at least 5% by weight based on the total amount of the inorganic fine powder component <I-1> as stated above. When it is less than 5% by weight, the exposure of the transparent inorganic fine powder component to the surface is not satisfactory, and it is hardly expected to release variable scattered luminescence.

The method of applying the asperity to the surface and exposing the transparent inorganic fine powder component thereto may include various methods. As a preferable method, for example, the resin component on the surface is effectively removed with a solvent capable of dissolving the resin component on the surface or by jetting pressure water of a water jet on the surface, after heat-molding under pressure through casting with a reverse decorating die.

By these methods, the artificial stone wall pane releases the scattered luminescence that is variable by illumination of natural light or artificial light and movement thereof. Such an artificial stone wall panel has been so far completely unknown. By the arrangement of the artificial stone wall panels, a desired glossy wall surface in combination with a less glossy or glossless wall surface can freely be designed easily.

In the invention of this application, the support for installation on the wall surface is integrally molded by being embedded in at least one of the back surface and the edge surface of the molded product as the artificial stone body.

In the artificial stone panel, at least a part of the support is exposed to at least one of the back surface and the edge surface of the panel or both thereof, whereby the installation on the wall surface is enabled.

The material of the support may include various materials such as a metal (including an alloy), a resin, a woody material, ceramics and a composite material of two or more thereof. Preferable is a material which is good in affinity for the foregoing artificial stone body texture and in adhesion thereto and excellent in weatherability, water resistance, strength, durability and the like. Its shape and structure may include various types. For example, it is considered that an engagement portion which allows screwing, bolting, nailing, riveting or the like and which can fix the panel from the back surface without boring or cutting the panel surface is formed or that a structure having a fixing portion protruded outside the edge surface is provided.

The support can be produced by being integrally molded with the artificial stone panel body. At this time,

the mixture of the foregoing composition for the panel body is filled in a lower mold, and the support and an upper mold are then pressed for mold-integrating.

In the molding, a pressure of, for example, 100 N/cm² or less is sufficient, and the pressure may actually be from 10 N/cm² to 30 N/cm². In consideration of the fillability in the lower mold or the moldability, it is preferable that two or more of the monomer, the oligomer and the polymer are used as the resin component in the mixture.

In the embedding of the support by the molding, it is generally preferable that the volume ratio except the portion protruded outside the artificial stone panel is 80% or less and the depth is 80% or less of the total thickness. When the volume ratio exceeds 80% and the depth exceeds 80%, characteristics as the wall panel, such as a strength, tend to be impaired, and the appearance of the surface lacks uniformity.

Figs. 1 to 8 attached hereto show sectional views and plane views of the panel back surface on the construction of the artificial stone panel in the invention of this application. Figs. 1 and 2 (case 1) illustrate the artificial stone panel and a steel frame (1) as the support. The steel frame (1) is combined with the artificial stone (2) by integrally molding. The

artificial stone panel is installed with steel pillars or studs (5) by rivets (4) or bolts through the bolting or riveting holes (3). Figs. 3 and 4 (case 2) illustrate the artificial stone panel and a support thereof comprising of a combination of a steel frame (1) and an irregularly finished steel plate (6). The support is combined with the artificial stone (2) by integrally molding. The artificial stone panel is installed with ALC wall (8) by bolts (7), etc through the bolting or riveting holes (3). Figs. 5 and 6 (case 3) illustrate the artificial stone panel and steel fittings (9) as the supports thereof. In these cases, steel fittings (9) are molded integrally with the artificial stone wall and installed with steel pillars or studs (5) by rivets (4) or bolts through the bolting or rivetting holes (3).

Figs. 7 and 8 (case 4) illustrate the artificial stone panel and an irregularly finished steel plate (6). In case 2 shown in Figs. 3 and 4, and case 4 shown in Figs. 7 and 8, the whole surface is integrally molded with the irregularly finished steel plate (6) to reduce the weight and secure the engagement portion while improving a bending strength or a fireproof performance.

As shown in Figs. 1 to 6 (cases 1 to 3) the engagement portion is rendered hollow for easy screwing or riveting.

Of course, regarding the engagement portion, the number, the position, the size (for example, a diameter and a length of a screw or a bolt) and the combination are not limited by these examples.

In any of these cases, according to the invention of this application, the artificial stone wall panel having the support embedded therein is realized as the integrally molded product free from warpage or cracks.

According to the invention of this application, for example, the artificial stone panel is actually realized on the basis of the following physical properties with large withdrawal destruction load of an embedded fitting portion or a support.

Bending strength (JIS A 5209) 285 N/cm or more

Vickers hardness 1050

Water absorption 0.1

Accelerated weatherability no abnormality

S. W. O. M (2000 hours)

SUV (500 hours) no abnormality

Acid resistance and alkali resistance (JIS A 5209)

no abnormality

Freezing and thawing test B method no abnormality

200 cycles

(JIS A 5422 "Ceramics siding")

Impact resistance test no abnormality

500 g 2000 mm

After dropping weight

(plate thickness 18, 21, 24 mm)

Thus, the invention of this application is illustrated more specifically below by referring to the Examples. Of course, the invention is not limited by the following Examples.

EXAMPLES

<Example 1>

The compositions shown in the following Table 1 were prepared. In this table, MMA indicates methyl methacrylate resin component, and the additives indicate a peroxide-type curing catalyst and a light stabilizer.

For each composition, mold-integration with a support as shown in Figs. 1 and 2 were performed under a pressure of 12 N/cm². Artificial stone panels having a total thickness of 23 mm and a height (depth) of 13 mm in the asperity (concavo-convex portion) was molded, using a steel frame having a thickness of 6 mm as the support. As a result, as shown in Table 1, the cure shrinkage factor was controlled to less than 0.2% for compositions 1 to 5 referring to the invention of the present application, and high-quality artificial stone panels completely free of warpage and cracks were obtained. Other properties as

wall material, such as a strength, were also good.

Meanwhile, for comparative compositions 1 to 3, warpage and fine cracks were observed, and these were not suitable as a wall panel.

Further, in compositions 1, 2 and 4 containing transparent fine powders, a pleasant design with a hitherto-unknown variable and scattering sparkle was identified.

Table 1

	Blending component (wt. %)	Composition 1	Composition 2	Composition 3	Composition 4	Composition 5	Composition 1	Composition 2	Comparative composition 3
A	Granite-type river sand	2.3	2.3	3.0	4.2	5.4		3.2	3.0
	Inorganic fine powder comp.								
B	Andesite-type crushed stone								
	inorganic fine powder comp.	20	40				28	16	40
C	Transparent inorganic fine powder comp. (quartz)	20	20	27					
D	Inorganic finely divided comp. (alumina hydroxide)	4.3	2.1	1.4	2.3	2.0	5.6	16	14
E	MMA	1.3	1.5	1.5	1.7	2.5	1.5	3.5	1.5
F	Additives, etc.	1	1	1	1	1	1	1	1
(A+B+C)/D		1/1	3/1	5/1	3/1	3.7/1	1/2	3/1	5/1
Cure shrinkage factor (%)	0.15	0.05	0.1	0.06	0.08	0.35	0.5	0.4	

(Notes) In compositions 1 to 5 and comparative compositions 1 and 2, the grain size of A, B and C is from 180 μm to 3.35 mm, and the grain size of D is less than 180 μm (average grain size: 70 μm).

In comparative composition 3,
the grain size of A, B and C is from 850 μm to 3.35 mm, and
the grain size of D is from 180 μm to less than 850 μm .

<Example 2>

The composition of the artificial stone body was as follows.

Resin component	20% by weight
(details)	methyl methacrylate 40%
	butyl methacrylate 30%
	acrylic resin 30%

Curing agent, etc. 1% by weight

Inorganic fine powder component

(180 μm to 5 mm)	58% by weight
(details)	transparent natural silica rock
	10%
	granite 90%

Inorganic finely divided component

21% by weight

Aluminum hydroxide

(less than 180 μm , average grain size 70 μm)

The ambient temperature-setting mixture of the foregoing composition was charged into a bottom mold, and a support (total heights: 10 mm) in combination with a steel frame (thickness: 6 mm) and an irregularly finished plate (heights: 10 mm) as shown in Figs. 3 and 4, were pressed with a top mold at a pressure of 10 N/cm² while applying vibration. The product was cured at room temperature for approximately 30 minutes.

After withdrawal from the molds, a mold-integrated artificial stone wall panel (total thickness: 23 mm) with a support embedded thereto was obtained. Neither warpage nor cracks were observed in this panel.

<Example 3>

An artificial stone wall panel was molded in accordance with the Example 2 using the steel fittings shown in Figs. 5 and 6 (case 3). Here, the steel fitting (Fig. 9) is made of SS41 coated with pentite (Zn). Sizes thereof (mm) are shown in Fig. 9. The total thickness of the artificial stone wall panel was 20 mm. Height (depth) of the asperity at the surface of the artificial stone was 10 mm. In this case, the withdrawal destruction load of the embedded steel fitting portion was 420 kgf/fitting.

For cases using steel fittings shown in Figs. 10 to 12 instead of the above mentioned steel fittings, each withdrawal destruction load of the embedded steel fitting was measured as follows;

steel fitting shown in Fig. 10 (SUS 304):

864 kgf

steel fitting shown in Fig. 11 (SUS 304):

1052 kgf

steel fitting shown in Fig. 12 (SUS 304):

733 kgf

INDUSTRIAL APPLICABILITY

As has been described in detail above, the invention of the present application provides, upon solving the foregoing problems associated with the prior art, a novel artificial stone wall panel as an external wall material with excellent design, while also simplifying installation to external wall thereby being advantageous in view of productivity, workability and cost, by mold-integrating an artificial stone and a support for installing such artificial stone to an external wall surface.

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